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Kurihara

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(54) **DEVELOPING DEVICE AND IMAGE FORMING APPARATUS**

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G03G 15/08 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/0891*** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/0891
USPC 399/254, 257
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0029405 A1 * 2/2006 Tanaka et al. 399/257

FOREIGN PATENT DOCUMENTS

JP 06332313 A * 12/1994
JP H09-218575 A 8/1997

* cited by examiner

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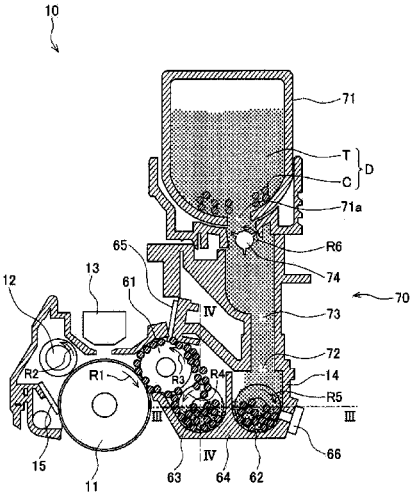
(57) **ABSTRACT**

A developing device according to the invention develops latent images formed on an image carrier with a developer including toner carrier and toner. The developing device includes a developer container, a developer conveying member, a supply unit, a discharge unit, and a discharge prohibiting unit. The developer container contains the developer. The developer conveying member conveys the developer contained in the developer container as stirring the developer to circulate the developer in a circulation path in the developer container. The supply unit supplies at least the toner carrier to the circulation path. The discharge unit discharges excessive developer in the circulation path according to supply from the supply unit. The discharge prohibiting unit prohibits discharge of the developer from the discharge unit during a predetermined discharge prohibiting period in a case where the toner carrier is supplied from the supply unit.

11 Claims, 15 Drawing Sheets



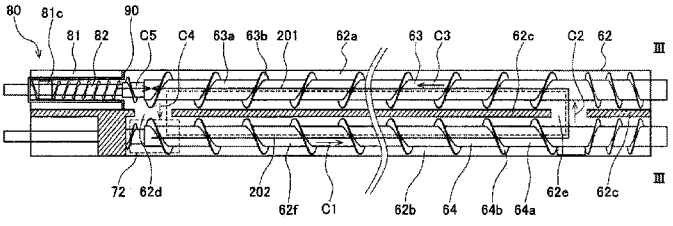


FIG. 1

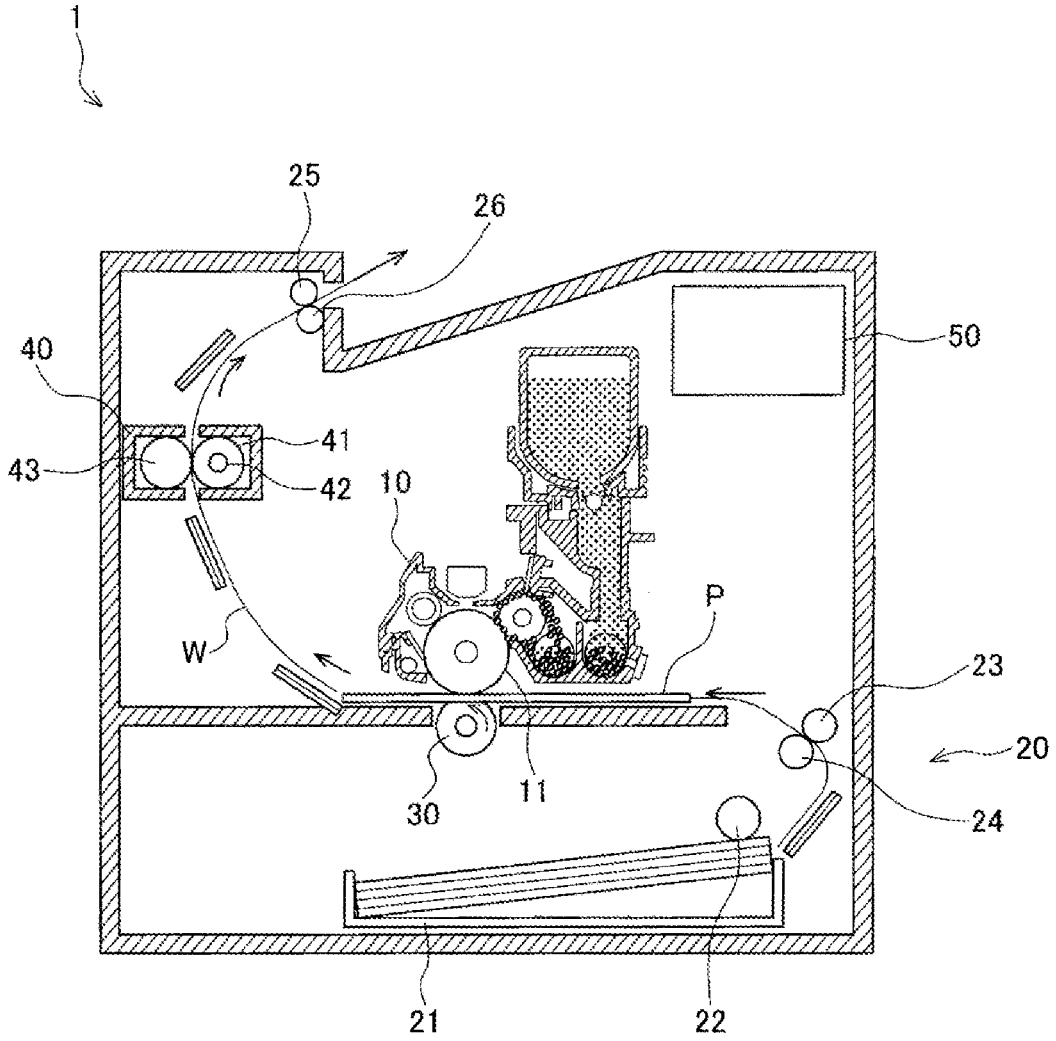


FIG. 2

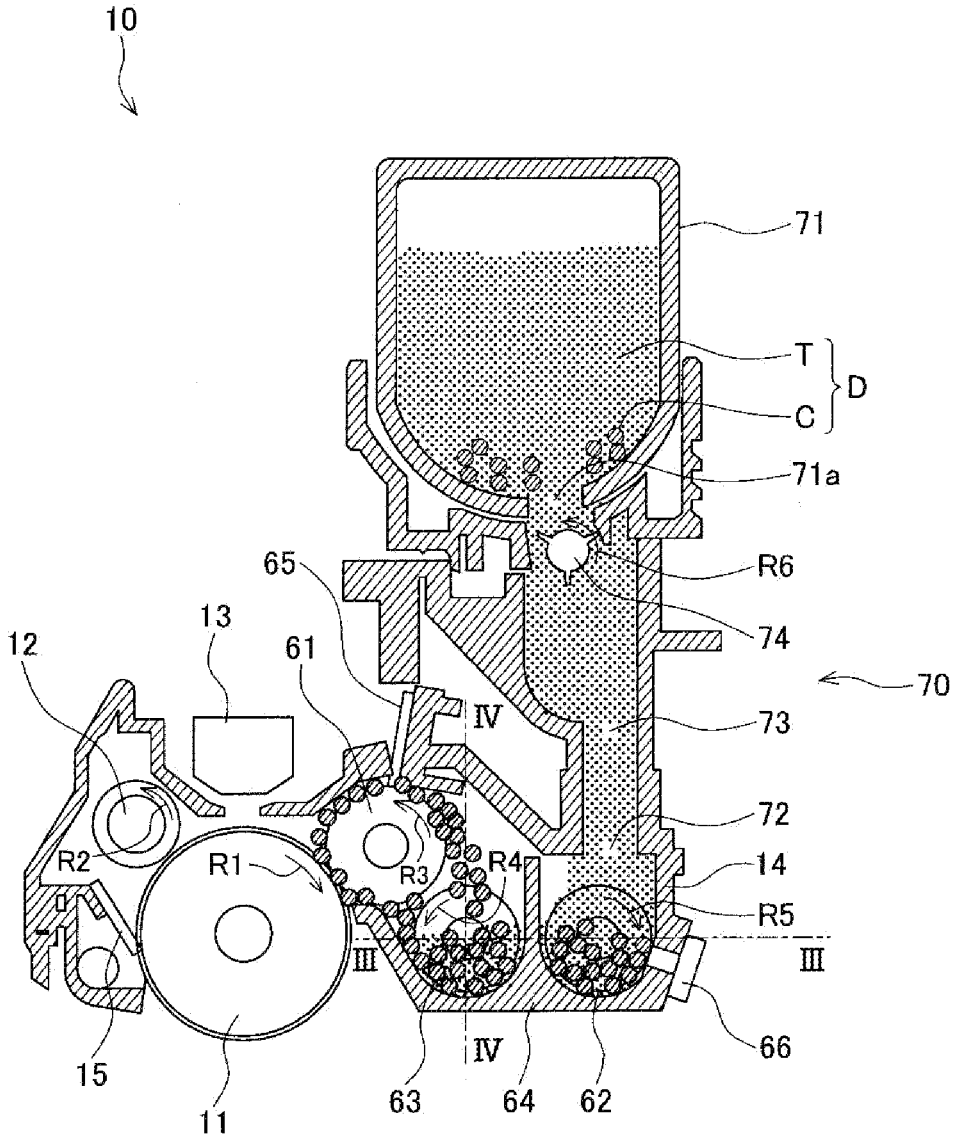
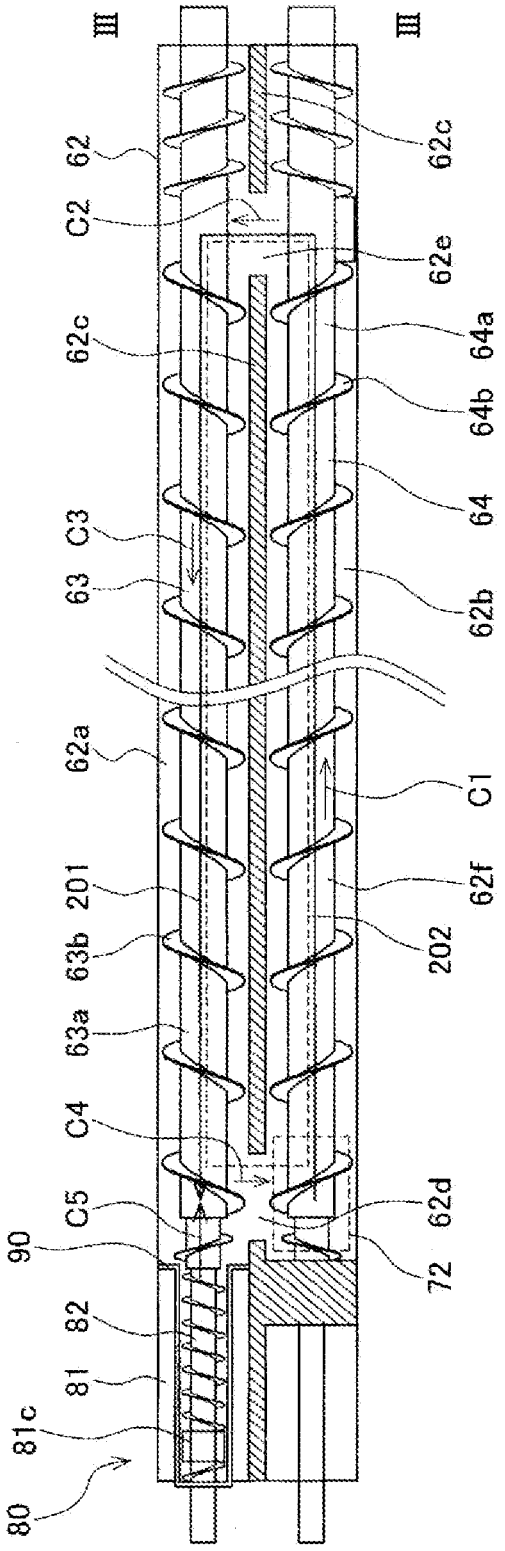

10
71
T
C
D
71a
65
R6
74
13
12
61
70
IV
73
72
R2
R1
R3
R4
14
R5
III
III
66
IV
15
11
63
64
62

FIG.3


III
III
62
C2
62c
62e
64a
64b
64
62b
C3
63
62a
C1
62f
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63b
63a
C4
C5
90
82
81
81c
80
62d
72

FIG.4A

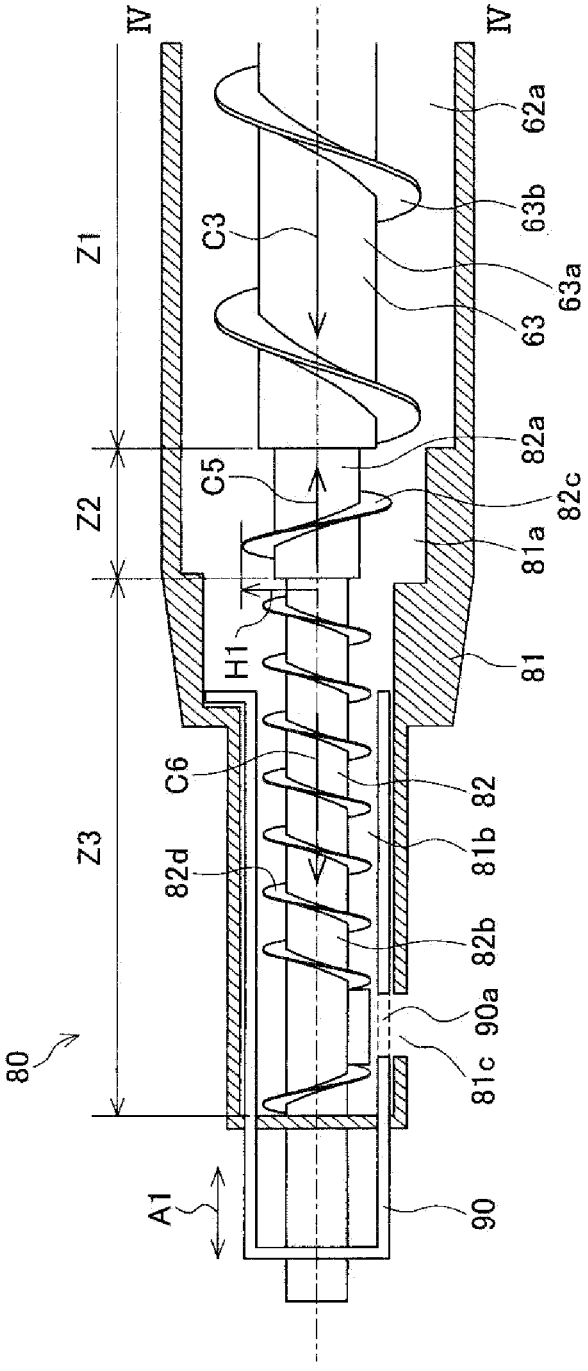
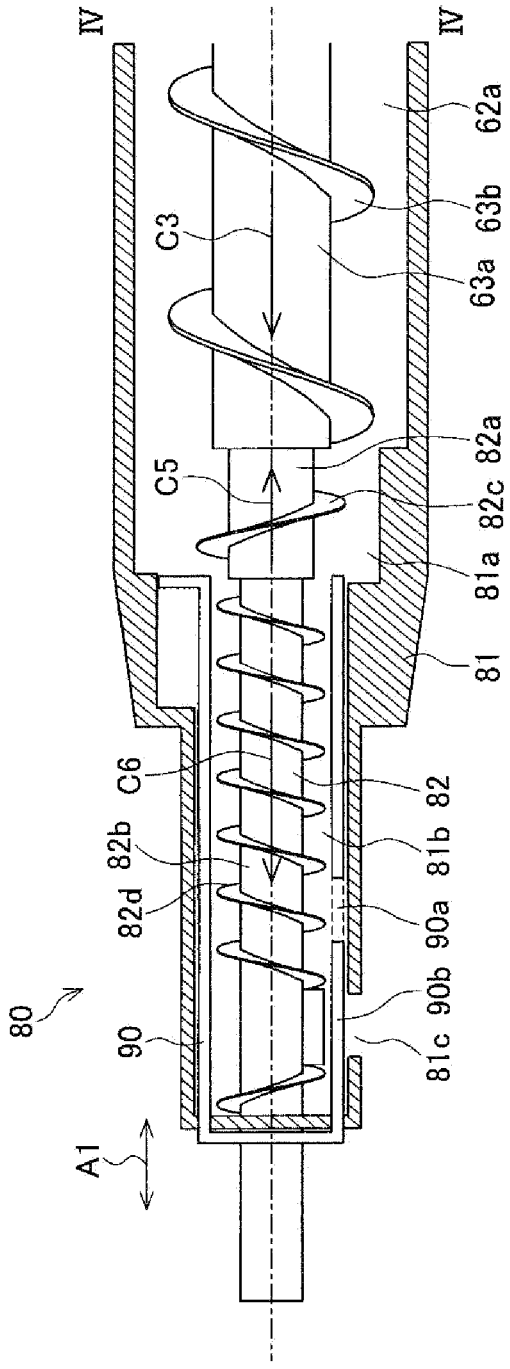

IV
IV
62a
63b
63a
63
C3
Z1
82a
82c
C5
Z2
81a
H1
81
C6
82
81b
Z3
82d
82b
90a
81c
80
A1
90

FIG.4B


IV
IV
62a
63b
C3
63a
82a
C5
82c
81a
81
C6
82
82b
81b
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90a
90b
80
90
81c
A1

FIG.5

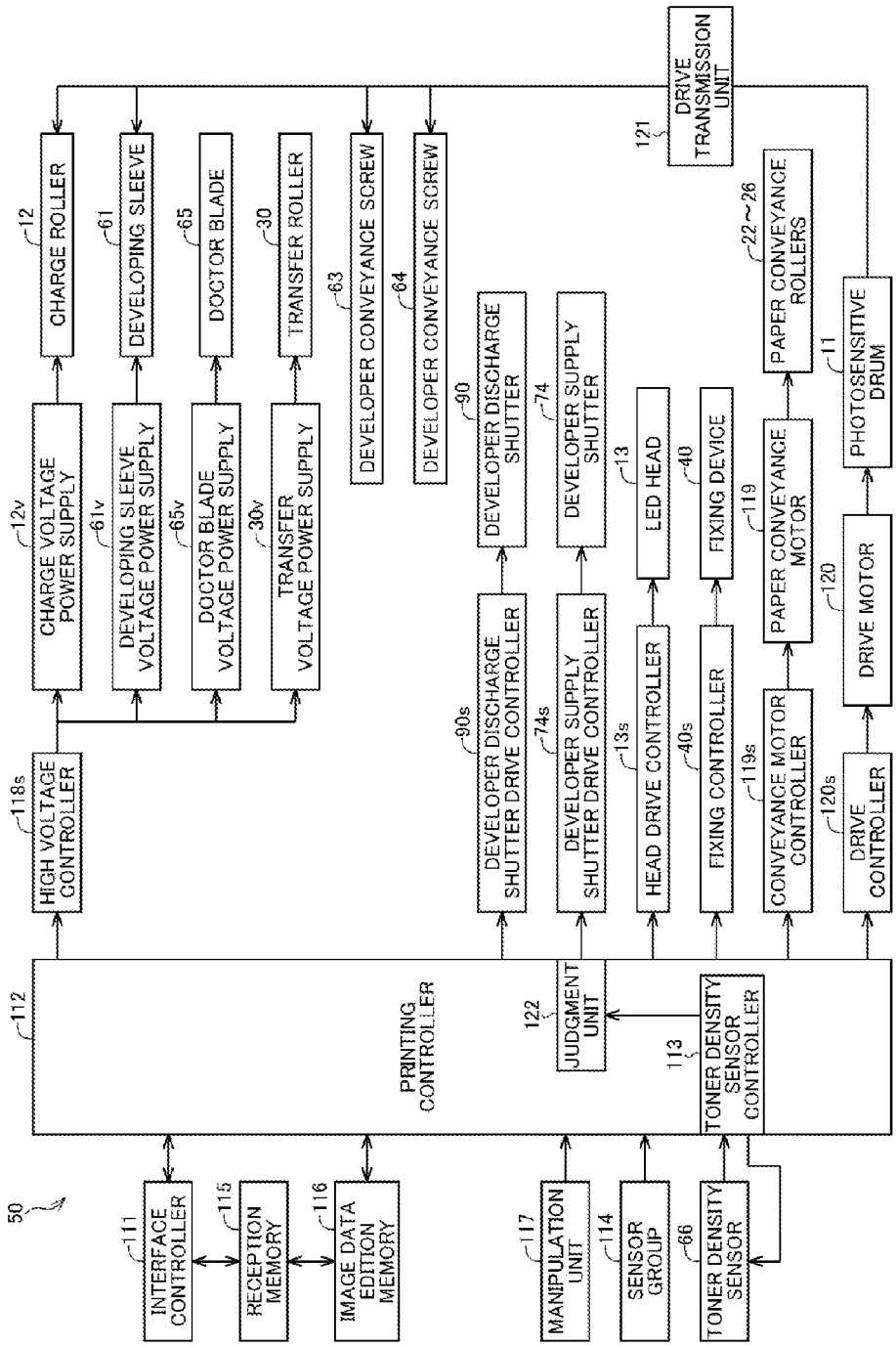

50
111 INTERFACE CONTROLLER
115 RECEPTION MEMORY
116 IMAGE DATA EDITION MEMORY
117 MANIPULATION UNIT
114 SENSOR GROUP
66 TONER DENSITY SENSOR
112 PRINTING CONTROLLER
122 JUDGMENT UNIT
113 TONER DENSITY SENSOR CONTROLLER
118s HIGH VOLTAGE CONTROLLER
12v CHARGE VOLTAGE POWER SUPPLY
61v DEVELOPING SLEEVE VOLTAGE POWER SUPPLY
65v DOCTOR BLADE VOLTAGE POWER SUPPLY
30v TRANSFER VOLTAGE POWER SUPPLY
90s DEVELOPER DISCHARGE SHUTTER DRIVE CONTROLLER
74s DEVELOPER SUPPLY SHUTTER DRIVE CONTROLLER
13s HEAD DRIVE CONTROLLER
40s FIXING CONTROLLER
119s CONVEYANCE MOTOR CONTROLLER
120s DRIVE CONTROLLER
12 CHARGE ROLLER
61 DEVELOPING SLEEVE
65 DOCTOR BLADE
30 TRANSFER ROLLER
63 DEVELOPER CONVEYANCE SCREW
64 DEVELOPER CONVEYANCE SCREW
90 DEVELOPER DISCHARGE SHUTTER
74 DEVELOPER SUPPLY SHUTTER
13 LED HEAD
40 FIXING DEVICE
119 PAPER CONVEYANCE MOTOR
120 DRIVE MOTOR
121 DRIVE TRANSMISSION UNIT
22~26 PAPER CONVEYANCE ROLLERS
11 PHOTOSENSITIVE DRUM

FIG.6

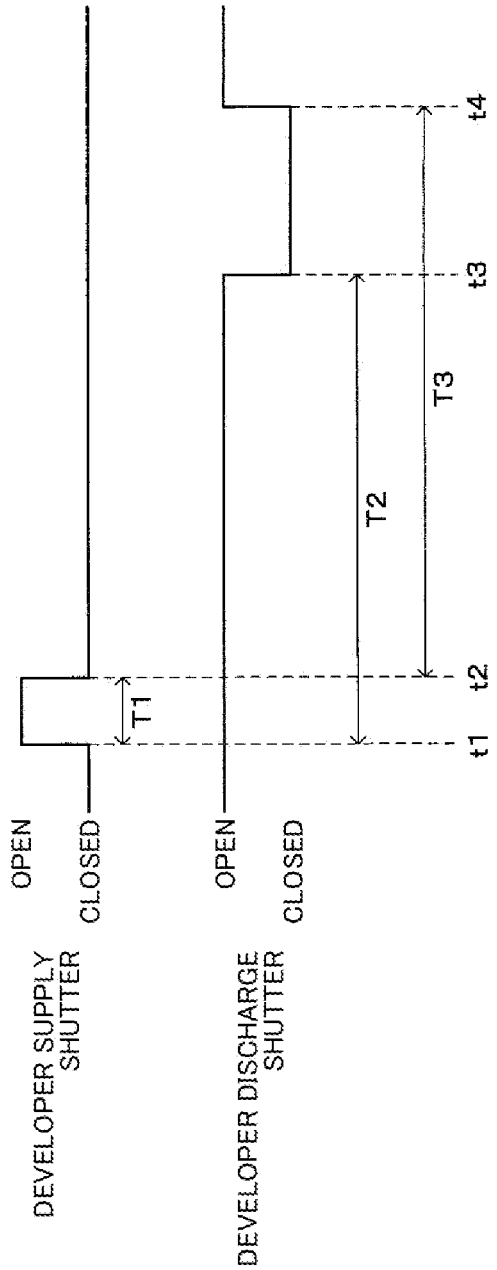

t4
t3
t2
t1
T3
T2
T1
OPEN
CLOSED
DEVELOPER SUPPLY SHUTTER
OPEN
CLOSED
DEVELOPER DISCHARGE SHUTTER

FIG.7

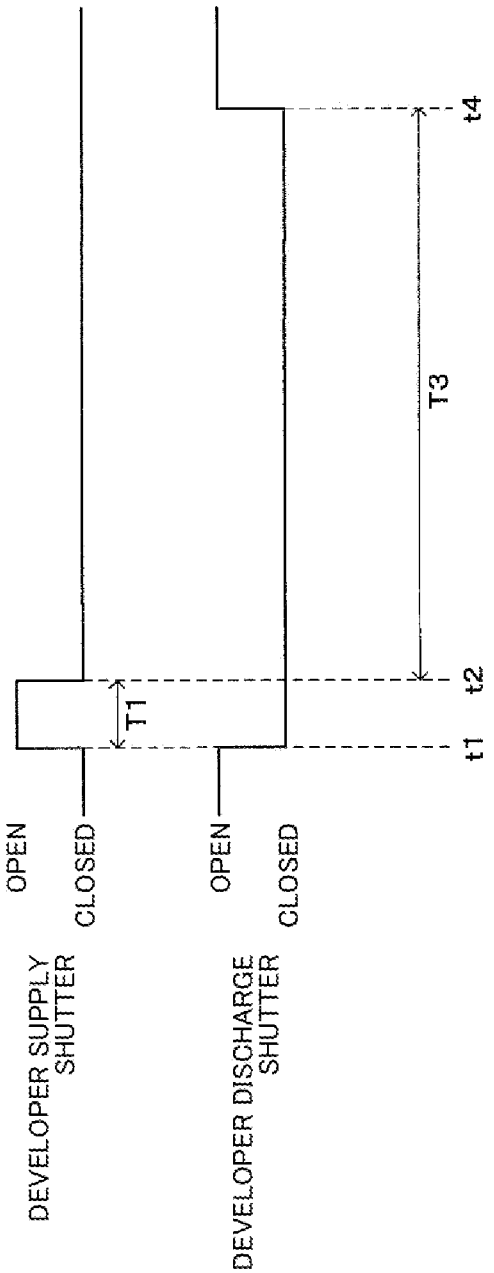

DEVELOPER SUPPLY SHUTTER
OPEN
CLOSED
DEVELOPER DISCHARGE SHUTTER
OPEN
CLOSED
T1
T3
t1
t2
t4

FIG.8

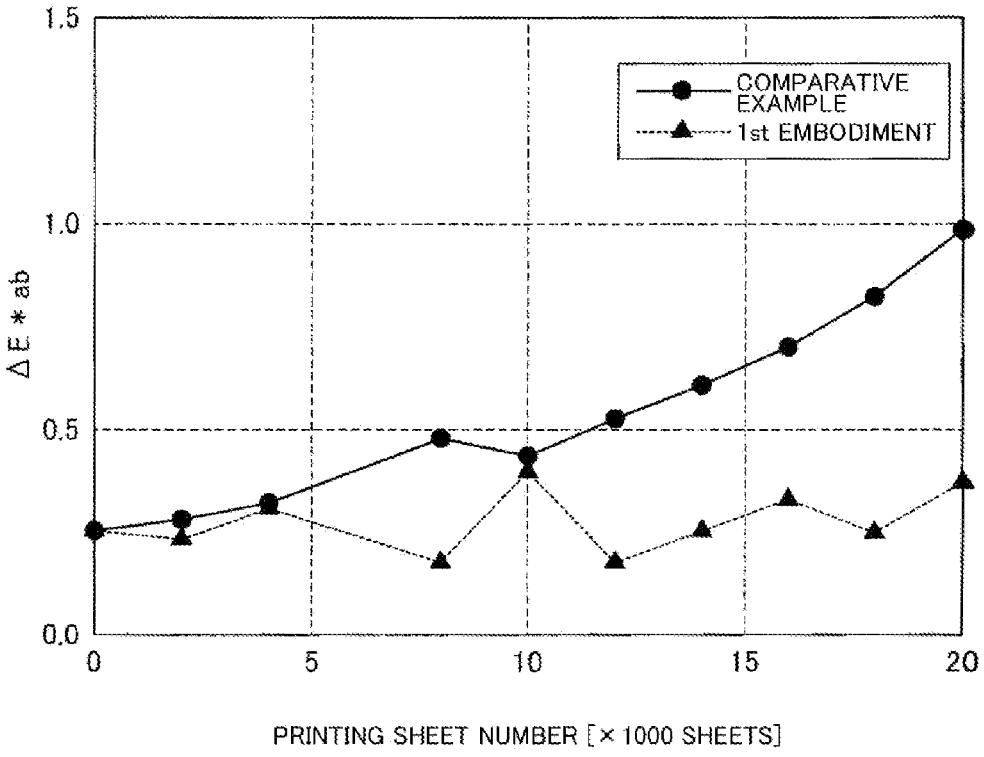

1.5
1.0
0.5
0.0
ΔE*ab
0
5
10
15
20
COMPARATIVE EXAMPLE
1st EMBODIMENT
PRINTING SHEET NUMBER [×1000 SHEETS]

FIG.9

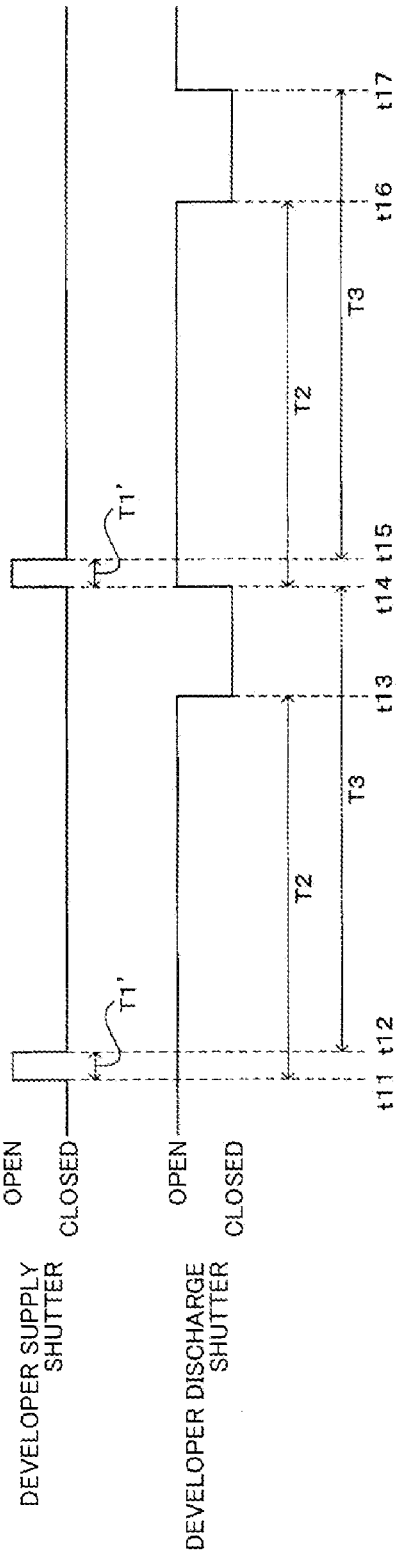
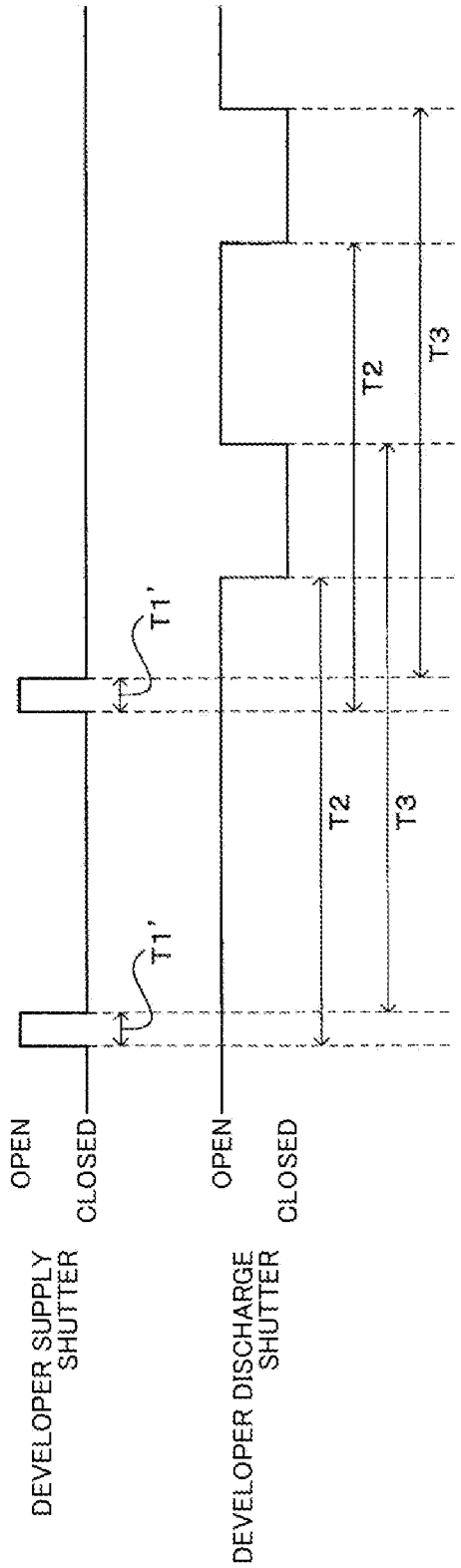

DEVELOPER SUPPLY SHUTTER
OPEN
CLOSED
DEVELOPER DISCHARGE SHUTTER
OPEN
CLOSED
T1'
T1'
T2
T2
T3
T3
t11
t12
t13
t14
t15
t16
t17

FIG.10A


T1'
T1'
T2
T3
T2
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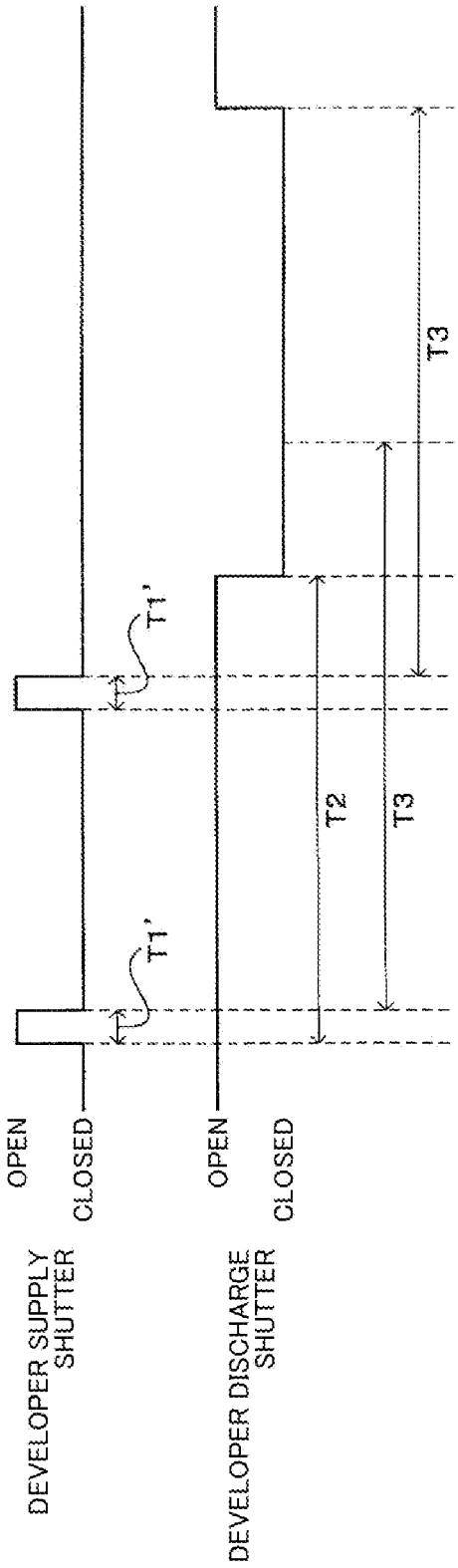
CLOSED
DEVELOPER SUPPLY SHUTTER
DEVELOPER DISCHARGE SHUTTER

FIG.10B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DEVELOPER DISCHARGE SHUTTER
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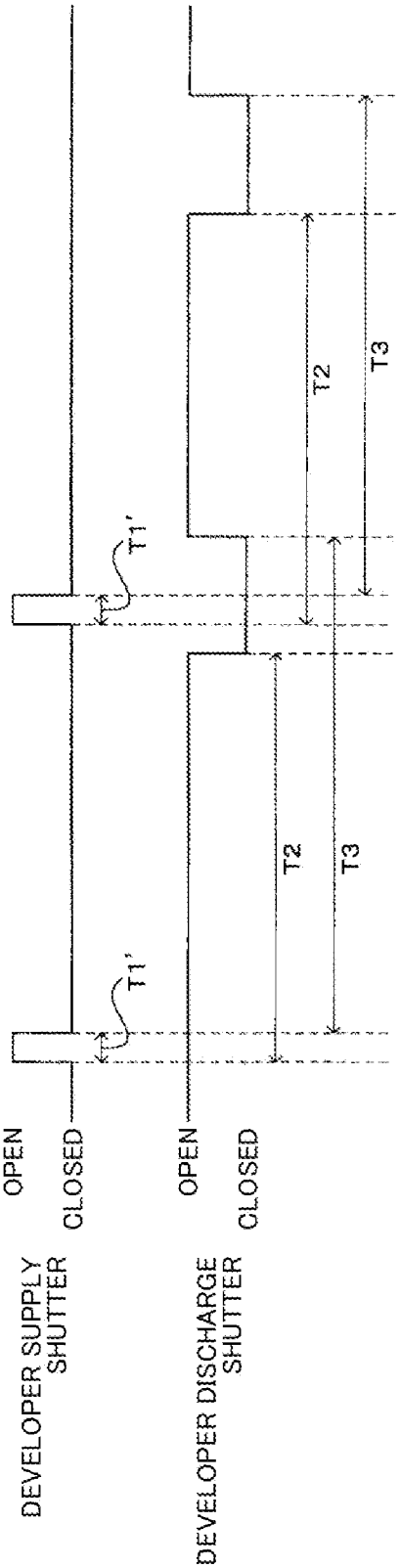
T1'
T1'
T2
T3
T3

FIG. 11A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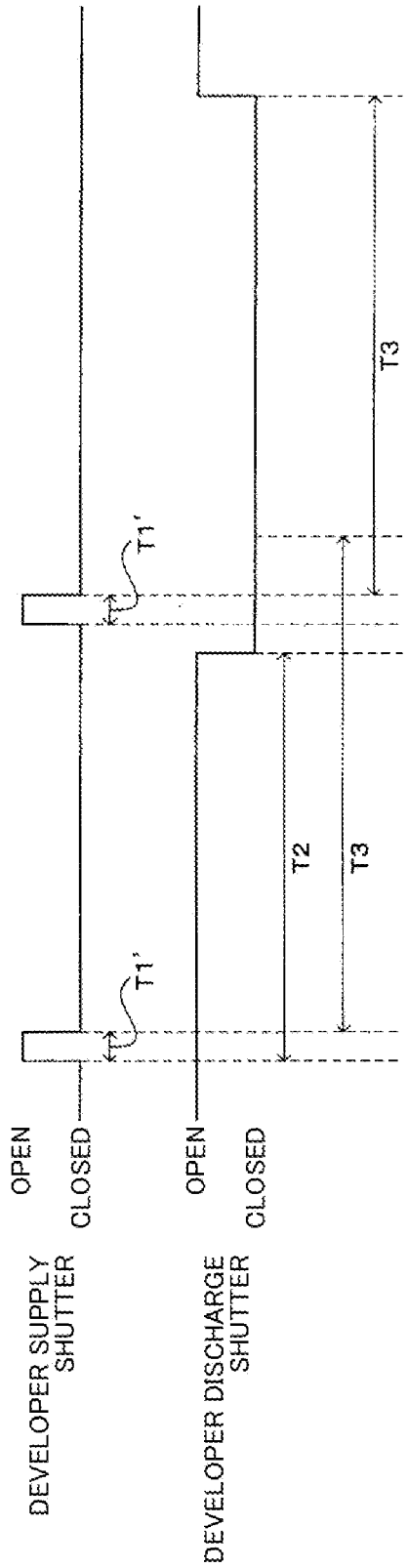
CLOSED
DEVELOPER DISCHARGE SHUTTER
OPEN
CLOSED
T1'
T1'
T2
T3
T2
T3

FIG.11B


DEVELOPER SUPPLY SHUTTER
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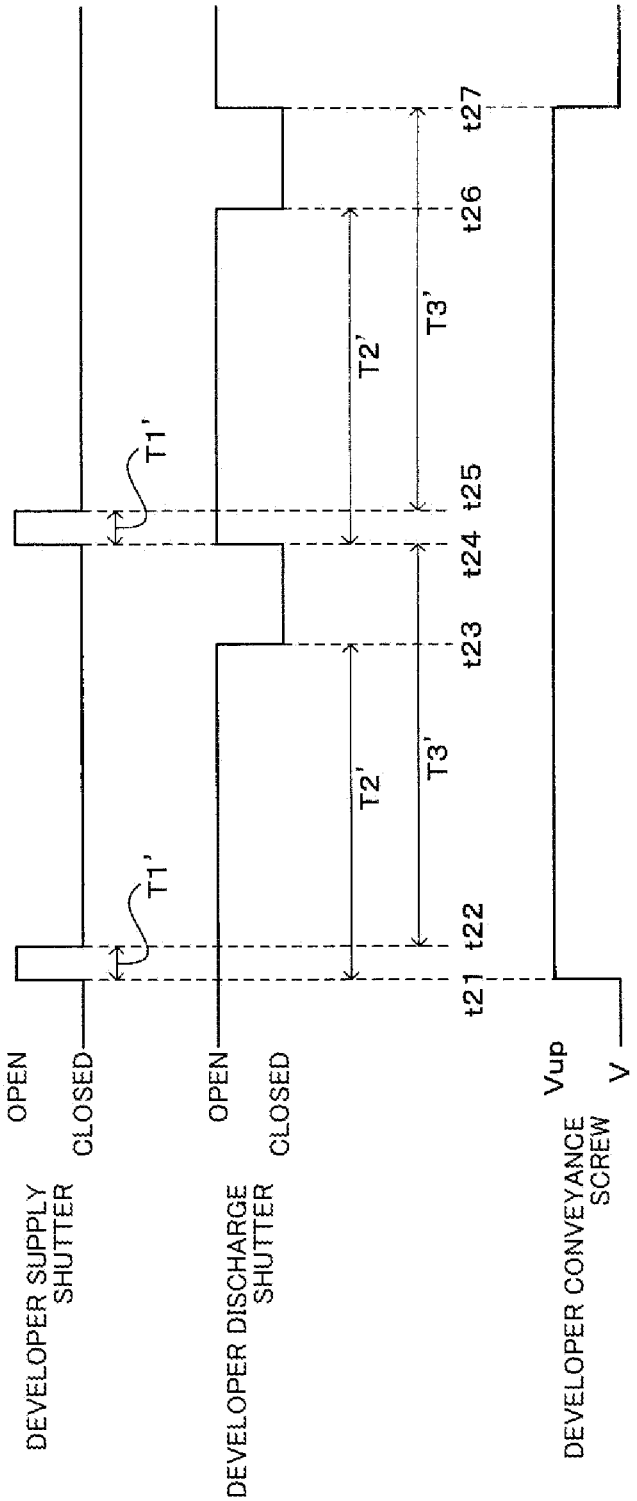
DEVELOPER DISCHARGE SHUTTER
OPEN
CLOSED
T1'
T1'
T2
T3
T3

FIG.12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t22
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t25
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t27
T1'
T2'
T3'
T1'
T2'
T3'
OPEN
CLOSED
DEVELOPER SUPPLY SHUTTER
OPEN
CLOSED
DEVELOPER DISCHARGE SHUTTER
Vup
V
DEVELOPER CONVEYANCE SCREW

DEVELOPING DEVICE AND IMAGE FORMING APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims priority benefits under 35 USC, section 119 on the basis of Japanese Patent Application No. 2014-061425, the disclosure of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a developing device and an image forming apparatus.

2. Description of Related Art

Among image forming apparatuses of electrophotographic method, a two-component development method in which latent images formed on an image carrier are developed using a developer including toner carrier and toner, has been known. With such a two-component development method, when the toner carrier is degraded along use, the toner carrier tends to have lower charge ability. A trickle development method in which excessive developer in the developer container is discharged while new developer is supplied to the developer container (see, e.g., Japanese Application Publication (A1) No. H9-218,575), has been proposed.

With such a trickle development method, however, if new toner carrier just supplied is discharged at a time that the toner carrier is supplied, a ratio of degraded toner carrier will increase as time goes, so that the quality of the images becomes low.

It is therefore an object of the invention to provide a developing device and an image forming apparatus capable of preventing new toner carrier just supplied from being discharged.

SUMMARY OF THE INVENTION

To solve the above problems, a developing device according to a first aspect of the invention, develops latent images formed on an image carrier with a developer including toner carrier and toner, and comprises a developer container containing the developer, a developer conveying member conveying the developer contained in the developer container as stirring the developer to circulate the developer in a circulation path in the developer container, a supply unit supplying at least the toner carrier to the circulation path, a discharge unit for discharging excessive developer in the circulation path according to supply from the supply unit, and a discharge prohibiting unit prohibiting discharge of the developer from the discharge unit during a predetermined discharge prohibiting period in a case where the toner carrier is supplied from the supply unit.

These and other objects, features, aspects and advantages of the present invention will become apparent to those skilled in the art from the following detailed description, which, taken in conjunction with the annexed drawings, discloses a preferred embodiment of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the attached drawings which form a part of this original disclosure:

FIG. **1** is a schematic diagram showing a structure of an image forming apparatus according to a first embodiment of the invention;

FIG. **2** is a schematic diagram showing a structure of an image forming section in the image forming apparatus shown in FIG. **1**;

FIG. **3** is a cross section cut along III-III line in FIG. **2**;

FIGS. **4**A, **4**B are cross sections cut along IV-IV line in FIG. **2**;

FIG. **5** is a block diagram showing the structure of the image forming apparatus according to the first embodiment;

FIG. **6** is a control sequence diagram of a developer supply shutter and a developer discharge shutter according to the first embodiment;

FIG. **7** is a control sequence diagram of a developer supply shutter and a developer discharge shutter according to a modification of the first embodiment;

FIG. **8** is a diagram showing an evaluation result of the first embodiment and a compared example;

FIG. **9** is a control sequence diagram of a developer supply shutter and a developer discharge shutter according to a second embodiment;

FIG. **10** A, **10**B are control sequence diagrams of a developer supply shutter and a developer discharge shutter according to a modification of the second embodiment;

FIG. **11** A, **11**B are control sequence diagrams of a developer supply shutter and a developer discharge shutter according to another modification of the second embodiment; and

FIG. **12** is a control sequence diagram of a developer supply shutter, a developer discharge shutter, and developer conveyance screws according to a third embodiment.

DETAILED DESCRIPTION OF EMBODIMENTS

Selected embodiments of the present invention will now be explained with reference to the drawings. It will be apparent to those skilled in the art from this disclosure that the following descriptions of the embodiments of the invention are provided for illustration only and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

First Embodiment

FIG. **1** is a schematic diagram showing a structure of an image forming apparatus **1** according to the first embodiment. The image forming apparatus **1** is an apparatus forming images on recording media using an electrophotographic method, and is, herein, a monochrome printer. In FIG. **1**, the image forming apparatus includes an image forming section **10**, a medium conveyance section **20**, a transfer roller **30** as a transfer device, a fixing device **40**, and a control device **50**.

The image forming apparatus **10** has a photosensitive drum **11** as an image carrier, and forms toner images onto the photosensitive drum **11**. The image forming apparatus **10** will be described in detail below.

The medium conveyance section **20** conveys a paper P as a recording medium and supplies the paper P to the image forming section **10**. The medium conveyance section **20** includes a container tray **21** for containing the paper P, a paper conveyance roller **22** for feeding sheet by sheet the paper P contained in the container tray **21**, and paper conveyance rollers **23** to **26** for conveying the paper P fed by the paper conveyance roller **22** along a conveyance route W in an arrow direction in FIG. **1**.

The transfer roller **30** transfers the toner images formed on the photosensitive drum **11** by means of the image forming

section **10** onto the paper P supplied from the medium conveyance section **20**. The transfer roller **30** is disposed facing the photosensitive drum **11** and forms a transfer section performing transfer to the photosensitive drum **11**. The transfer roller **30** is formed of, e.g., a metal shaft or core covered with a urethane sponge layer.

The fixing device **40** fixes, to the paper P, toner images transferred onto the paper P by the transfer roller **30**. The fixing device **40** includes a heating roller **41**, a heater **42** heating the heating roller **41**, and a pressure roller **43** applying pressure to the heating roller **41**. When the paper P passes between the heating roller **41** and the pressure roller **43**, the fixing device **40** fixes the toner images onto the paper P upon application of heat and pressure.

The control device **50** controls operations of the image forming apparatus **1**. The control device **50** will be described below in detail.

FIG. **2** is a schematic diagram showing a structure of the image forming section **10**. In FIG. **2**, the image forming section **10** includes the photosensitive drum **11**, a charge roller **12** as a charge device, an LED head **13** as a latent image forming unit or an exposing device, a developing device **14**, and a cleaning blade **15** as a cleaning device.

The photosensitive drum **11** is a member carrying latent images and toner images. More specifically, the photosensitive drum **11** is a cylindrical member extending in a longitudinal direction, or namely in a direction perpendicular to a drawing surface of FIG. **2**. The photosensitive drum **11** has a gear or gears for drive, not shown, and rotates in arrow R**1** direction in FIG. **2** according to drive force given from the gears. The photosensitive drum **11** is constituted of a conductive support and a photoconductive layer. For example, the photosensitive drum **11** is an organic photosensitive body having a metal pipe made of aluminum as the conductive support accumulating, as the photoconductive layer, a charge generation layer and a charge transfer layer. Around the photosensitive drum **11**, provided along the rotational direction R**1** are the charge roller **12**, the LED head **13**, the developing device **14**, the transfer roller **30**, and the cleaning blade **15**, in this sequence.

The charge roller **12** charges the surface of the photosensitive drum **11**. The charge roller **12** is disposed in contact or pressurized contact with the surface of the photosensitive drum **11**. The charge roller **12** is a cylindrical member and rotates in an arrow direction R**2** in FIG. **2**. The charge roller **12** is made of, e.g., a metal shaft covered with a semiconductive epichlorohydrin rubber layer.

The LED head **13** forms latent images on the photosensitive drum **11**. More specifically, the LED head **13** is disposed facing the photosensitive drum **11**, and exposes the surface of the photosensitive drum **11** charged by the charge roller **12**, thereby forming the electrostatic latent images on the surface.

The developing device **14** develops the latent images formed on the photosensitive drum **11** using a developer D including toner carrier C and toner T. The developing device **14** is a developing device for a trickle development method. Herein, the toner T is made of binding resin, charge controlling agent as internal additive, mold releasing agent, colorant, and external additive. The toner carrier C is a magnetic carrier and is made of particles having magnetism.

The cleaning blade **15** is a member removing toner remaining on the surface of the photosensitive drum **11** after the transfer, and is made of, e.g., an urethane rubber.

Hereinafter, the structure of the developing device **14** is described in detail. The developing device **14** includes a developing sleeve **61**, a developing container **62**, developer conveyance screws **63**, **64** serving as developer conveyance members, a doctor blade **65** serving as a thin layer forming device, and a toner density sensor **66** serving as a toner density detector.

The developing sleeve **61** carries the developer D and develops the latent images formed on the photosensitive drum **11** with the developer D, thereby forming the toner image on the photosensitive drum **11**. More specifically, the developing sleeve **61** is a cylindrical member extending along the longitudinal direction of the photosensitive drum **11**. The developing sleeve **61** is disposed facing the photosensitive drum **11** with a prescribed gap (herein, 500 micron meters). The developing sleeve **61** has a gear or gears for drive, not shown, and rotates in the arrow direction R**3** in FIG. **2** according to the drive force given from the gears. The developing sleeve **61** is made of, e.g., a metal pipe whose surface is finished with blasting treatment, and at an inside of the pipe, a magnetic body is placed for generating a prescribed magnetic flex density distribution on the developing sleeve **61**.

The developing container **62** contains the developer D supplied to the developing sleeve **61**. FIG. **3** is a cross section cut along III-III line in FIG. **2**, and shows the structure of the developing container **62** schematically. As shown in FIG. **3**, the developing container **62** has a first conveyance path **62***a*, a second conveyance path **62***b*, and a partition member **62***c*. The first conveyance path **62***a* and the second conveyance path **62***b* are passages for conveying the developer D and extend in the longitudinal direction of the developing sleeve **61**. The first conveyance path **62***a* is disposed so adjacently to the developing sleeve **61** that the developer D located inside the path is supplied to the developing sleeve **61**. The second conveyance path **62***b* is provided on the opposite side to the developing sleeve **61** with respect to the first conveyance path **62***a*. The partition member **62***c* extends along the longitudinal direction of the developing sleeve **61**, and divides the space into the first conveyance path **62***a* and the second conveyance path **62***b*. Openings **62***d*, **62***e* are formed near each end of the partition member **62***c* respectively for communicating the first conveyance path **62***a* with the second conveyance path **62***b*.

The developer conveyance screws **63**, **64** convey the developer D contained in the developing container **62** as stirring the developer and make the developer D circulate in a circulation path **62***f* within the developing container **62**. In the example shown in FIG. **3**, the developer conveyance screws **63**, **64** are structured to render the developer D in the developing container **62** circulate through the second conveyance path **62***b*, the opening **62***e*, the first conveyance path **62***a*, and the opening **62***d* in this sequence as shown with arrows C**1** to C**4**. That is, the circulation path **62***f* is formed of the second conveyance path **62***b*, the opening **62***e*, the first conveyance path **62***a*, and the opening **62***d*.

More specifically, the developer conveyance screw **63** is disposed in the first conveyance path **62***a*. The developer conveyance screw **63** includes a rotation shaft **63***a* extending along the first conveyance path **62***a*, and a vane **63***b* formed around the rotation shaft **63***a* within the first conveyance path **62***a*. The rotation shaft **63***a* is rotatably supported to the developing container **62** at each end in the longitudinal direction of the shaft. The developer conveyance screw **63** has a gear or gears for drive, and rotates in an arrow R**4** direction in FIG. **2** according to drive force given to the gear.

The developer conveyance screw **64** is disposed within the second conveyance path **62***b*. The developer conveyance screw **64** includes a rotation shaft **64***a* extending along the second conveyance path **62***b*, and a vane **64***b* formed around the rotation shaft **64***a*. The rotation shaft **64***a* is rotatably supported to the developing container **62** at each end in the

longitudinal direction of the shaft. The developer conveyance screw **64** has a gear or gears for drive, and rotates in an arrow R**5** direction in FIG. **2** according to drive force given to the gear.

The vanes **63***b*, **64***b* of the developer conveyance screws **63**, **64** are structured so that the developer D in the developer container **62** circulates through the circulation path **62***f* when the developer conveyance screws **63**, **64** rotate.

As viewed from FIG. **2**, the doctor blade **65** limits a layer thickness of the developer D on the developing sleeve **61**, and forms a thin layer of the developer D on the developing sleeve **61**. The doctor blade **65** is disposed fading the developing sleeve **61** on a downstream side of the developing container **62** and on an upstream side of the photosensitive drum **11** in the rotation direction R**3** of the developing sleeve **61**. A prescribed gap (herein 600 micron meters) is formed between the developing sleeve **61** and the doctor blade **65**. The doctor blade **65** is made of, e.g., a metal.

The toner density sensor **66** detects the toner density in the developer D in the developing container **62**. The toner density sensor **66** is a permeability detection type sensor, and detects the toner density by measuring the permeability of the developer D in the developing container **62**.

The developing device **14** further includes a supply unit **70** for supplying the developer D into the circulation path **62***f* of the developing container **62**, and a discharge unit **80** for discharging or discarding excessive developer D in the circulation path **62***f* due to supply from the supply unit **70**.

The supply unit **70** includes a developer cartridge **71**, a developer supply inlet **72**, a developer supply path **73**, and a developer supply shutter **74**.

The developer cartridge **71** is a developer container containing the developer D to be supplied in which the toner carrier C and the toner are mixed with a prescribed ratio. The developer cartridge **71** is disposed above the developing container **62**. A discharge outlet **71***a* for discharging the developer D is formed below the developer cartridge **71**.

The developer supply inlet **72** is an opening for supplying the developer D from the developer cartridge **71** to the developing container **62**. The developer supply inlet **72** is formed at a top of the developing container **62** as shown in FIG. **2**. As shown in FIG. **3**, the developer supply inlet **72** is formed near the opening **62***d* on one end side of the second conveyance path **62***b*.

The developer supply path **73** is a path introducing the developer D contained in the developer cartridge **71** into the developer container **62**. The developer supply path **73** makes the discharge outlet **71***a* of the developer cartridge **71** and the developer supply inlet **72** communicate each other.

The developer supply shutter **74** is a member opening and closing the discharge outlet **71***a* of the developer cartridge **71**. The developer supply shutter **74** is made open while developer D is supplied from the developer cartridge **71** to the developing container **62**, and is made closed other than that. The developer supply shutter **74** is herein a shutter of a rotary type, and discharges the developer D in the developer cartridge **71** toward the developer supply path **73** according to rotation in the arrow R**6** direction in FIG. **2**.

The discharge unit **80** discharges the developer D of an excessive portion which exceeds the prescribed amount, in a case where the developer D in the circulation path **62***f* exceeds the prescribed amount due to supply of the developer D from the supply unit **70**. The discharge unit **80** is constituted of a discharge side end **81** of the developing container **62** and a discharge side end **82** of the developer conveyance screw **63**.

FIG. **4** is a cross section cut along Iv-Iv in FIG. **2** and shows the structure of the discharge unit **80** schematically. FIG. **4**A shows a state that the discharge of the developer D done by the discharge unit **80** is allowed, and FIG. **4**B shows a state that the discharge of the developer D done by the discharge unit **80** is prohibited.

As shown in FIG. **4**, the discharge side end **81** of the developing container **62** includes a discharge developer selection path **81***a* in communication with the first conveyance path **62***a*, a discharge developer conveyance path **81***b* in communication with discharge developer selection path **81***a*, and a developer discharge outlet **81***c*. In FIG. **4**, sections Z**1**, Z**2**, and Z**3** are sections indicating the first conveyance path **62***a*, the discharge developer selection path **81***a*, and the discharge developer conveyance path **81***b*, respectively. The developer discharge outlet **81***c* is located at an end of the discharge developer conveyance path **81***b* opposite to the discharge developer selection path **81***a*, and is formed below the discharge developer conveyance path **81***b*.

The discharge side end **82** of the developer conveyance screw **63** includes a discharge developer selection unit **82***a* located in the discharge developer selection path **81***a*, and a discharge developer conveyance unit **82***b* located in the discharge developer conveyance path **81***b*. The discharge developer selection unit **82***a* has a vane **82***c* orienting oppositely to the orientation of the vane **63***b* on the side of the first conveyance path **62***a*, and generates conveyance force in a direction (arrow C**5** direction in FIG. **4**) opposite to the conveyance force (arrow C**3** direction in FIG. **4**) of the developer D in the first conveyance path **62***a*. The vane **82***c* has a height H**1** extending from, as a reference, a center axis line of the rotation shaft **63***a* of the developer conveyance screw **63**. The discharge developer conveyance unit **82***b* has a vane **82***d* orienting in the same direction to the orientation of the vane **63***b* on the side of the first conveyance path **62***a*, and generates conveyance force in the same direction (arrow C**6** direction in FIG. **4**) to the conveyance force (arrow C**3** direction in FIG. **4**) of the developer D in the first conveyance path **62***a*. The discharge developer conveyance unit **82***b* conveys, in the arrow C**6** direction, the developer D passing over the discharge developer selection unit **82***a*, and discharges the developer D out of the developing container **62** from the developer discharge outlet **81***c*.

Where the supply unit **70** supplies the developer D to the developing container **62**, if the developer D containing new toner carrier C just supplied is discharged from the discharge unit **80**, the ratio of the degraded toner carrier C in the developer D increases, thereby making the image quality low. More specifically, when the developer D is supplied, the volume of the developer locally increases at a portion that the developer D is supplied, the developer D including the toner carrier C newly just supplied and not degraded may be discharged at the discharge unit **80**. In such a case, the degraded toner carrier C and the not degraded toner carrier C may not be replaced efficiently with each other, and the ratio of the degraded toner carrier may increase. The charge amount of the toner is, therefore, deviated, and fogging in which toner attaches to non-printing portions on the photosensitive drum **11** may occur.

With the embodiment, from a viewpoint preventing new toner carrier C just supplied from being discharged, the developing device **14** includes a developer discharge shutter **90** as a discharge prohibiting unit. The developer discharge shutter **90** is controlled by the control device **50**, and prohibits or cut off the discharge of the developer D out of the discharge unit **80** during a prescribed discharge prohibiting period where the developer D is supplied from the supply unit **70**. More specifically, the developer discharge shutter **90** is a member rendering the developer discharge outlet **81***c* open and closed,

and closes the developer discharge outlet **81***c* when prohibiting the developer D from discharging, whereas making the outlet **81***c* open other than the above situation. Herein, the developer discharge shutter **90** is a cylindrical member inserted into discharge developer conveyance path **81***b*, and the discharge opening **90***a* is formed at a part of a lower portion of the shutter **90**. The developer discharge shutter **90** has a gear or gears for drive, not shown, and moves in the arrow A**1** direction in FIGS. **4**A, **4**B according to drive force given to the gear between an opening position shown in FIG. **4**A and a closed position shown in FIG. **4**B. The discharge opening **90***a* of the developer discharge shutter **90** and the developer discharge outlet **81***c* coincide to each other at the opening position, thereby allowing discharge of the developer D out of the developer discharge outlet **81***c*. To the contrary, a wall portion **90***b* of the developer discharge shutter **90** closes the developer discharge outlet **81***c* at the closed position, thereby prohibiting the developer D from discharging out of the developer discharge outlet **81***c*.

FIG. **5** is a block diagram showing a structure of the image forming apparatus **1**. Hereinafter, referring to FIG. **5**, a structure relating to the control of the image forming apparatus **1** is described.

In FIG. **5**, the control device **50** includes an interface (I/F) controller **111**, a printing controller **112**, a reception memory **115**, an image data edition memory **116**, a manipulation unit **117**, a high voltage power supply controller **118***s*, a charge voltage power supply **12***v*, developing sleeve voltage power supply **61***v*, a doctor blade voltage power supply **65***v*, a transfer voltage power supply **30***v*, a developer supply shutter drive controller **74***s*, a developer discharge shutter drive controller **90***s*, a head drive controller **13***s*, a fixing controller **40***s*, a conveyance motor controller **119***s*, and a drive controller **120***s*.

The interface controller **111** receives print data and control commands from a host apparatus such as, e.g., a personal computer, not shown.

The printing controller **112** receives the print data and the control commands from the host apparatus via the interface controller **111**, controls the entire sequences of the image forming apparatus **1**, and makes printing of the print data. The printing controller **112** is structured of, e.g., a microprocessor, ROMs (Read Only Memory), RAMs (Random Access Memory), input and output ports, and a timer. The printing controller **112** has a toner density sensor controller **113**. The toner density sensor controller **113** controls the control voltage of the toner density sensor **66**, thereby retrieving the detection result of the toner density sensor **66**. The printing controller **112** is connected to a sensor group **114**, and controls operation of the image forming apparatus **1** based on the output from the sensor group **114**. The sensor group **114** includes various sensors for monitoring operation of the image forming apparatus **1** and status of the periphery of the apparatus **1**, such as, e.g., a paper position detection sensor for detecting the position original document the paper P in the conveyance path W, a temperature and humidity sensor for detecting temperature and humidity of a surrounding of the image forming apparatus **1**, a printing density sensor for detecting the density of the toner image formed by the image forming unit **10**, and a developer remaining amount detection sensor for detecting the remaining amount of the developer D in the developer cartridge **71**.

The reception memory **115** temporarily memorizes printing data entered from the host apparatus via the interface controller **111**.

The image data edition memory **116** receives the printing data memorized in the reception memory **115**, and memorizes the image data produced by edition processing on the printing data.

The manipulation unit **117** receives the instructions from an operator. The manipulation unit **117** has a display unit displaying information for the operator such as, e.g., a status of the image forming apparatus **1**, and an input unit such as, switches, for receiving instructions from the operator.

The high voltage power supply controller **118***s*, controls the voltage applying to respective portions of the image forming apparatus **1** according to the instruction from the printing controller **112**.

The charge voltage power supply **12***v* applies a voltage designated from the high voltage power supply controller **118***s* to the charge roller **12**. The charge voltage power supply **12***v* applies a voltage designated from the high voltage power supply controller **118***s* to the charge roller **12**. The developing sleeve voltage power supply **61***v* applies a voltage designated from the high voltage power supply controller **118***s* to the developing sleeve **61**. The doctor blade voltage power supply **65***v* applies a voltage designated from the high voltage power supply controller **118***s* to the doctor blade **65**. The transfer voltage power supply **30***v* applies a voltage designated from the high voltage power supply controller **118***s* to the transfer roller **30**.

The developer supply shutter drive controller **74***s* controls the opening and closing operations of the developer supply shutter **74** formed with the developer cartridge **71** according to the instructions from the printing controller **112**. The developer discharge shutter drive controller **90***s* controls the opening and closing operations of the developer discharge shutter **90** formed with the developing device **14** according to the instructions from the printing controller **112**.

The head drive controller **13***s* sends image data memorized in the image data edition memory **116** to the LED head **13** and drives the LED head **13**.

The fixing controller **40***s* supplies electric power to the fixing device **40** to fix the toner images transferred onto the paper P to the paper P. More specifically, the fixing controller **40***s* reads the output of the temperature sensor not shown for detecting the temperature of the heating roller **41**, and based on the output, controls a current passage to the heater **42** so as to make the heating roller **41** at a constant temperature.

The conveyance motor controller **119***s* controls a paper conveyance motor **119** for driving the paper conveyance rollers **22** to **26**, and conveys as well as stops the paper P at a prescribed timing according to the instructions from the printing controller **112**.

The drive controller **120***s* drives a drive motor **120** for rotating the photosensitive drum **11** according to the instructions from the printing controller **112**. Drive force from the drive motor **120** is transmitted to a drive transmission unit **121** via the photosensitive drum **11**, and further transmitted to the charge roller **12**, the developing sleeve **61**, and the developer conveyance screws **63**, **64**, by the drive transmission unit **121**.

Next, functions of the printing controller **112** regarding the supply and discharge of the developer D are described.

The printing controller **112** has a judgment unit **122** judging as to whether the developer D is to be supplied based on a use state of the developer D in the circulation path **62***f* or the developing container **62**. In this embodiment, the judgment unit **122** judges as the developer D is to be supplied where the toner density is lower than a predetermined threshold value based on the detection consequence of the toner density sensor **66**. The judgment unit **122**, however, can make a judgment with other methods, and for example, can make a judgment as

to supply the developer D when the accumulated printing sheet number or accumulated printing dot number exceeds each threshold value.

Where the judgment unit **122** judges that the developer D is to be supplied, the printing controller **112** makes open the developer supply shutter **74** for a prescribed period from the developer supply shutter drive controller **74***s*. With this operation, the supply unit **70** supplies the developer D in a prescribed amount into the circulation path **62***f*. In this embodiment, the prescribed amount is variable and is decided according to the images to be printed. More specifically, the printing controller **112**, based on the image data memorized in the image data edition memory **116**, makes longer the open period of the developer supply shutter **74** and makes more the supply amount of the developer D, as more the dot number to be printed exists. The prescribed amount can be a predetermined fixed value.

Where the supply unit **70** supplies the developer D, the printing controller **112** makes closed the developer discharge shutter **90** during the prescribed discharge prohibiting period from the developer discharge shutter drive controller **90***s*. With this operation, the developer discharge shutter **90** serving as a discharge prohibiting unit prohibits the developer D from discharging out of the discharge unit **80** during the discharge prohibiting period.

The discharge prohibiting period includes at least a part of a period that the toner carrier C supplied from the supply unit **70** passes through the discharge unit **80**. Herein, the period that the toner carrier C supplied from the supply unit **70** passes through the discharge unit **80** means a period from a timing that the supplied toner carrier C reaches the discharge unit **80** to a timing that the toner carrier C finishes passing through the discharge unit **80**, and more particularly, the passing period means a period from a timing that a front end of the distribution of the supplied toner carrier C reaches the discharge unit **80** to a timing that a rear end of the distribution of the supplied toner carrier C finishes passing through the discharge unit **80**, because the supplied toner carrier C is conveyed as stirred by the developer conveyance screws **63**, **64** and made spread in the conveyance direction.

In one embodiment, a start timing of the discharge prohibiting period is prior to a timing that the toner carrier C supplied from the supply unit **70** reaches the discharge unit **80**. An end timing of the discharge prohibiting period is subsequent to a timing that the toner carrier C supplied from the supply unit **70** passes through the discharge unit **80**.

In operation of the image forming apparatus **1**, with reference to FIGS. **1** to **5**, if a printing command is entered from the host apparatus, the printing controller **112** drives the drive motor **120** via the drive controller **120***s*, and rotates the photosensitive drum **11** in the arrow R direction at a constant circumferential speed. Where the drive transmission unit **121** transmits the drive force from the rotation of the photosensitive drum **11**, the charge roller **12** rotates in the arrow R**2** direction; the developing sleeve **61** rotates in the arrow R**3** direction; and the developer conveyance screws **63**, **64** rotate in the arrows R**4**, R**5** directions, respectively. The printing controller **112** applies a voltage from the charge voltage power supply **12***v* to the charge roller **12** via the high voltage power supply controller **118***s* and charges the surface of the photosensitive drum **11** uniformly. The printing controller **112** then drives the LED head **13** via the head drive controller **13***s* based on the image data memorized in the image data edition memory **116**. With this operation, light corresponding to the image data is radiated from the LED head **13** to the charged surface of the photosensitive drum **11**, thereby forming latent images onto the photosensitive drum **11**. The electrostatic latent images formed on the photosensitive drum **11** are developed with the toner T according the development operation of the developing device **14** as described below, and toner images are formed onto the photosensitive drum **11**.

To the contrary, the paper P contained in the container tray **21** is conveyed by the paper conveyance rollers **22** to **24**, and sent to a transfer unit located between the photosensitive drum **11** and the transfer roller **30**. The transfer roller **30** receives application of a direct current voltage from the transfer voltage power supply **30***v*, and transfers the toner images formed on the photosensitive drum **11** onto the paper P. The paper P with the transferred toner images is further conveyed to the fixing device **40**. At the fixing device **40**, the toner images on the paper P are melt in application of heat and pressure, immerged into fibers of the paper P, and fixed to the paper P. The paper P with the fixed toner images is sent out of the image forming apparatus **1** by means of the paper conveyance rollers **25**, **26**.

The toner T in a certain amount may remain on the surface of the photosensitive drum **11** after the transfer operation. The remaining toner T is removed by the cleaning blade **15**. The surface of the photosensitive drum **11** after cleaning operation is used for image formation again, and thus, the photosensitive drum **11** is used repetitively.

Hereinafter, referring to FIG. **2** and FIG. **3**, the development operation of the developing device **14** is described. In the developing container **62**, the developer D is conveyed as stirred with the developer conveyance screws **63**, **64**. The toner T, at that time, is charged at a prescribed polarity (i.e., negative in this embodiment) according to friction with the toner carrier C. The developer D in the first conveyance path **62***a* is drawn up with the developing sleeve **61** to which the developing sleeve voltage power supply **61***v* applies a prescribed voltage (e.g., −500 V) according to magnetic force from the developing sleeve **61**. The drawn-up developer D forms magnetic bristles from a prescribed magnetic flux density distribution on the developing sleeve **61**. The magnetic bristles formed on the developing sleeve **61** are sliced to have a proper length by means of the doctor blade **65** to which the doctor blade voltage power supply **65***v* applies a prescribed voltage (e.g., −500 V). The developer D formed on the developing sleeve **61** passing through the doctor blade **65** reaches a portion facing the photosensitive drum **11** according to the rotation of the developing sleeve **61**. The toner T charged negatively in the developer D is attached to the electrostatic latent images formed on the photosensitive drum **11** at the facing portion, thereby forming toner images on the photosensitive drum **11**. In this embodiment, the developing sleeve **61** and the doctor blade **65** are set to the same potential, but can be set with a potential difference to charge them at a time that the developer D is sliced.

Next, referring to FIGS. **2**, **3**, supply operation of the developer D is described. The developer D supplied onto the developing sleeve **61** from the first conveyance path **62***a* is collected again into the first conveyance path **62***a* after the toner T is consumed through the development operation. The collected developer D is conveyed along the circulation path **62***v* with the developer conveyance screws **63**, **64**, and the toner density in the conveyed developer D is detected with the toner density sensor **66**. Where judging that the toner density detected by the toner density sensor **66** is lower than a preset threshold value, the printing controller **112** makes open the developer supply shutter **74**, thereby supplying the developer D in the developer cartridge **71** from the developer supply inlet **72** to the second conveyance path **62***b*. The supplied developer D is conveyed as stirred with the developer conveyance screws **63**, **64** and mixed with the existing developer

D. As described above, the developer D is supplied from the developer cartridge **71** so as to maintain the desired toner density.

Referring to FIGS. **2**, **4**, discharge operation of the developer D is described. According to the supply of the developer D from the supply unit **70**, the amount of the developer D in the developing container **62** increases. With this increased amount, if the height of the developer D exceeds the height H of the vane **82***c* of the developer conveyance screw **63** in the discharge developer selection path **81***a* (section Z2 in FIG. **4**), the conveyance force in the arrow C**5** direction in FIG. **4** does not work the portion exceeding the height H, and the developer D of the portion exceeding the height H is conveyed to the discharge developer conveyance path **81***b* (section Z**3** in FIG. **4**). The developer D is conveyed in the arrow C**6** direction in FIG. **4** according to the vane **82***d* of the developer conveyance screw **63**, and is discharged from the discharge opening **90***a* and the developer discharge outlet **81***c*. The discharged developer D is preserved in the discharge developer storing container, not shown. As described above, the developing device **14** discharges the developer D so as to maintain the desired developer amount.

FIG. **6** is a control sequence diagram of a developer supply shutter **74** and a developer discharge shutter **90**, and shows timings of opening and closing of each shutter. Hereinafter, referring to FIG. **6**, the discharge prohibiting operation of the developer D is described.

The printing controller **112** makes the developer supply shutter **74** open at a timing t**1**. The developer D is supplied at the same time as the developer supply shutter **74** is made open, and the supplied developer D is conveyed along the circulation path **62***f*.

The printing controller **112** measures lapse time from the timing t**1**, and makes the developer supply shutter **74** closed at a timing that the measured lapse time reaches time T**1** or namely timing t**2**. With this operation, the supply of the developer D is stopped. The time T**1** is determined according to, e.g., image data to be printed.

The printing controller **112** makes closed the developer discharge shutter **90** at a timing that the lapse time from the timing t**1** reaches a time T**2** or namely at a timing t**3**. In this embodiment, the time T**2** is a required time for the toner carrier C supplied from the supply unit **70** to reach the discharge unit **80**, or specifically, the discharge developer selection path **81***a*, and the timing t**3** is a time point that the toner carrier C supplied from the supply unit **70** reaches the discharge unit **80**. The required time may be measured through experiments or may be calculated. For example, where a distance along the circulation path **62***f* from the developer supply inlet **72** to the discharge developer selection path **81***a*, or a length of a route **201** shown with a solid line in FIG. **3**, is set to S, and where a conveyance speed of the toner carrier C is set to Vd, the time T**2** is calculated from a formula (i) below.

$$T2=S/Vd \quad \text{(i)}$$

The conveyance speed Vd is measured from, e.g., experiments. Herein, because the toner carrier C supplied from the supply unit **70** is conveyed as stirred and mixed well, the conveyance speed of the toner carrier C is not uniform, and generates a certain distribution. In consideration of this distribution, the maximum value of the conveyance speed distribution of the toner carrier C is used for the conveyance speed Vd in the formula (i) so as not to discharge the toner carrier C first reaching the discharge unit **80**. In a case that the conveyance speed distribution has a narrow width, an average value may be used.

The printing controller **112** measures lapse time from the timing t**2**, and makes open the developer discharge shutter **90** at a timing that the measured lapse time reaches the time T**3** or namely at a timing t**4**. In this embodiment, the time T**3** is a required time for the toner carrier C supplied from the supply unit **70** to circulate once around the conveyance path **62***f*. More specifically, the timing t**4** is a time point that a rear end of the distribution of the toner carrier C supplied from the supply unit **70** reaches again a portion of the developer supply inlet **72**. The required time may be measured through experiments or may be calculated. For example, where a length of the circulation path **62***f*, or a length of a route **202** shown with a broken line in FIG. **3**, is set to L, and where a conveyance speed of the toner carrier C is set to Vd, the time T**3** is calculated from a formula (ii) below.

$$T3=L/Vd \quad \text{(ii)}$$

In consideration of the distribution of the conveyance speed of the toner carrier C, the minimum value of the conveyance speed distribution of the toner carrier C is used for the conveyance speed Vd in the formula (ii). In a case that the conveyance speed distribution has a narrow width, an average value may be used.

In FIG. **6**, a period from the timing t**3** to the timing t**4** is the discharge prohibiting period, and the developer D is prohibited from being discharged during the discharge prohibiting period.

The controls of the developer supply shutter **74** and the developer discharge shutter **90** as described above are performed during the printing operation, but may be performed during a period other than the printing operation, such as, e.g., a period after printing operation.

It is to be noted that with the structure described above, a time shorter than the required time that the toner carrier C supplied from the supply unit **70** reaches the discharge unit **80** may be set as the time T**2**. As shown in FIG. **7**, the printing controller **112** may make the developer discharge shutter closed at the timing t**1**. That is, the start timing of the discharge prohibiting period can be the same timing as the start of the supply of the developer D done by the supply unit **70**. The term "same timing" herein means not only "perfectly the same timing" but also "substantially the same timing." The discharge prohibiting period thus may start simultaneously with the supply start of the developer D by the supply unit **70**.

The time T**3** may be set to a required time for the toner carrier C supplied from the supply unit **70** to completely pass through the discharge unit **80** or namely the discharge developer selection path **81***a* or to a time longer than the required time. For example, an adequately long time can be set as the time T**3** so that the developer discharge shutter **90** is made open after the developer D in the circulation path **62***f* becomes uniform.

The following evaluations were made to confirm advantages of the embodiment. In these evaluations, the image forming apparatus **1** according to the first embodiment was used under the circumstance of the temperature 23 degrees Celsius and the relative humidity 45%, with a setting of a printing speed 200 mm/s, which is equal to the line speed of the photosensitive drum **11** and the conveyance speed of the paper P, to perform printing of 20,000 sheets in lateral feed (i.e., two longer edges among four edges become front and rear ends) of A4 standard paper (e.g., excellent white paper made by Oki Data Corp., 80 g/m^2 as basis weight) with 5% duty. It is to be noted that an indication of 100% duty means a printing of the 100% area ratio made over a printable range of an A4 single sheet paper with a whole range solid printing.

During this test, evaluations of fogging were made at each printing of 2,000 sheets. For the evaluations of fogging, a blank image was printed, and the power for the image forming apparatus **1** was turned off while the paper P was passing a portion perpendicularly below the photosensitive drum **11**, thereby compulsively stopping the apparatus. With this state, the toner on the surface of the photosensitive drum **11** after the development but before the transfer was attached to an adhesive tape (i.e., a Scotch Tape [trademark] made of 3M Japan Limited). The adhesive tape attached with the toner and an adhesive tape attached with no toner were pasted on the same paper, and a color difference Δ(delta) E*ab of the L*a*b color system of those adhesive tapes was measured using a spectral colorimeter (CM-2600d, Konica Minolta, Inc made). If the measured color difference ΔE*ab was equal to or less than 0.5, the image quality was judged as good, whereas if the color difference was more than 0.5, the image quality was judged as no good.

As a comparative example, substantially the same evaluations were made under a condition that the developer discharge shutter **90** of the image forming apparatus **1** was made in a normally open state.

FIG. **8** shows evaluation consequences of the embodiment and the comparative example. For the comparative example, fogging was made worse at 12,000 sheets or later. It was assumed that this was caused from increased degraded toner carrier. To the contrary, this embodiment did not show any worse state of fogging even at 12,000 sheets or later, and obtained a good image quality even upon reaching 20,000 sheets.

As described above, the embodiment, under the trickle development method, is formed with the developer discharge shutter **90** (or namely the discharge prohibiting unit), and where the toner carrier C is supplied from the supply unit **70**, discharge of the developer D from the discharge unit **80** is prohibited during the prescribed discharge prohibiting period. With this operation, the developing device can prevent newly just supplied toner carrier C from being discharged. Accordingly, the toner carrier C supplied can be used efficiently, and the developing device can obtain the good image quality for a long period of time, thereby making itself and the image forming apparatus having a longer duration.

According to the structure that discharge of the developer D is prohibited at the same time as the supply start of the developer D done by the supply unit **70**, the toner carrier C supplied from the supply unit **70** can be prevented from discharged from the discharge unit **80** in passing through the opening **62***d* immediately after supply start.

Second Embodiment

Hereinafter, an image forming apparatus according to the second embodiment is described. The image forming apparatus has a different supply control of the developer D in comparison with the image forming apparatus according to the first embodiment, and other portions are substantially the same. In the following description, descriptions of portions substantially the same as those in the first embodiment are omitted or simplified, and elements the same as or corresponding to those in the first embodiment are given with the same reference numbers.

In this embodiment, if the judgment unit **122** judges that the developer D is to be supplied, the supply unit **70** supplies multiple times the developer D in a prescribed amount in an intermittent and dividing manner. For example, the supply unit **70** performs N times operation supplying the developer D in a supply amount of X/N (N is an integer of two or more) in a case where the developer D in a prescribed amount of X is supplied. More specifically, when judging that the developer D is to be supplied, the printing controller **112** decides an open time Ts of the developer supply shutter **74** according to the image data to be printed, and performs N times operation opening the developer supply shutter **74** only for a time of Ts/N.

FIG. **9** is a control sequence diagram of the developer supply shutter **74** and the developer discharge shutter **90** according to the second embodiment. FIG. **9** shows a situation that the developer D in the same amount as that in FIG. **6** is supplied in a manner dividedly twice.

The printing controller **112** makes open the developer supply shutter **74** at a timing t**11**, and makes closed the developer supply shutter **74** at a timing that the lapse time from the timing t**11** reaches a time T**1'** (=T**1**/**2**), or namely at a timing t**12**. The printing controller **112** makes closed the developer discharge shutter **90** at a timing that the lapse time from the timing t**11** reaches a time T**2**, or namely at a timing t**13**, and makes open the developer discharge shutter **90** at a timing that the lapse time from the timing t**12** reaches a time T**3** or namely at a timing t**14**.

The printing controller **112** starts the supply operation of the second time at the same time as the completion of the supply operation of the first time. The supply operation of the second time is substantially the same as the supply operation of the first time, and supply is made from a timing t**14** to a timing t**15** whereas discharge is prohibited from a timing t**16** to a timing t**17**.

As described above, the developer D is supplied multiple times in a divided manner in this embodiment. That is, the developer D is supplied intermittently. With this operation, the developer D or the toner carrier C can be uniformly distributed in the circulation path **62***f* in comparison with the device supplying the developer D once. It is to be noted that the time interval of the supply may be set in an appropriate manner, and can be set longer or shorter than the time interval shown in FIG. **9**.

FIGS. **10**A, **10**B are control sequence diagrams of the developer supply shutter **74** and the developer discharge shutter **90** according to a modification of the second embodiment. In FIGS. **10**A, **10**B, the supply of the second time is done after the supply of the first time but before the developer discharge shutter **90** is made closed.

In FIG. **10**A, the printing controller **112** performs opening and closing operations of the developer discharge shutter **90** according to the following rules (a1) to (a4):

(a1) starting the measurement of the lapse time To at a time opening the developer supply shutter **74**;

(a2) starting the measurement of the lapse time Tc at a time closing the developer supply shutter **74**;

(a3) closing the developer discharge shutter **90** when the lapse time To reaches the time T**2**; and

(a4) opening the developer discharge shutter **90** when the lapse time Tc reaches the time T**3**.

In FIG. **10**B, the printing controller **112** performs opening and closing operations of the developer discharge shutter **90** according to the following rule (a5) in addition to the rules (a1) to (a4):

(a5) resetting the measurement of the lapse time Tc and stopping operation, if the developer supply shutter **74** is made open again before the lapse time Tc reaches the time T**3** after starting the measurement of the lapse time Tc.

FIGS. **11**A, **11**B are control sequence diagrams of the developer supply shutter **74** and the developer discharge shutter **90** according to another modification of the second embodiment. In the modified example shown in FIGS. **11**A,

11B, the supply of the second time is performed while the developer discharge shutter **90** is in the closed state after the supply of the first time is done. The opening and closing operations of the developer discharge shutter **90** is performed according to the above rules (a1) to (a4) in a device corresponding to FIG. **11**A and according to the above rules (a1) to (a5) in a device corresponding to FIG. **11**B, in a manner similar to those corresponding to FIGS. **10**A, **10**B.

Third Embodiment

Hereinafter, an image forming apparatus according to the third embodiment is described. This image forming apparatus is different from the image forming apparatus according to the second embodiment in respect with changing control of conveyance speed of the developer D, and other portions are substantially the same between the second and the third embodiments. In the following description, descriptions of portions substantially the same as those in the second embodiment are omitted or simplified, and elements the same as or corresponding to those in the second embodiment are given with the same reference numbers.

The printing controller **112** raises the conveyance speed of the developer D done by the developer conveyance screws **63**, **64** during a prescribed period where the developer D is supplied from the supply unit **70**. More specifically, the printing controller **112** increases the conveyance speed while the supply unit **70** supplies multiple times the developer D in the prescribed amount in a divided manner. The printing controller **112** increases the conveyance speed during the discharge prohibiting period. In this embodiment, the printing controller **112** increases the conveyance speed of the developer D between the start timing of the supply of the first time and the end timing of the discharge prohibiting period corresponding to the supply of Nth time, where the developer D is supplied N times in the divided manner.

FIG. **12** is a control sequence diagram of the developer supply shutter **74**, the developer discharge shutter **90**, and the developer conveyance screws **63**,**64** according to the third embodiment. FIG. **12** shows a situation in which the developer D in the same amount as that shown in FIG. **6** is supplied dividedly twice.

The printing controller **112** makes open the developer supply shutter **74** at a timing t**21**, and makes closed the developer supply shutter **74** at a timing that the lapse time from the timing t**21** reaches a time T**1'** (=T**1**/**2**), or namely a timing t**22**.

The printing controller **112** changes the rotation speed of the developer conveyance screws **63**, **64** from V to Vup, which is higher than V, at the same time as the opening of the developer supply shutter **74**, or namely at the timing t**21**. With this change, the conveyance speed of the developer D is increased.

The printing controller **112** makes closed the developer discharge shutter **90** at a timing that the lapse time from the timing t**21** reaches the time T**2'** or namely at a timing t**23**. In this embodiment, the time T**2'** is a required time that the toner carrier C supplied from the supply unit **70** reaches the discharge unit **80**, and the timing t**23** is a time point that the toner carrier C supplied from the supply unit **70** reaches the discharge unit **80**. The required time may be measured through experiments or may be calculated. For example, where a distance along the circulation path **62***f* from the developer supply inlet **72** to the discharge developer selection path **81***a* is set to S, and where a conveyance speed of the toner carrier C is set to Vdup, the time T**2'** is calculated from a formula (iii) below.

$$T2'=S/Vdup \quad \text{(iii)}$$

The conveyance speed Vdup is a conveyance speed of the developer D where the rotation speed of the developer conveyance screws **63**, **64** is Vup, and is measured through, e.g., experiments. The conveyance speed Vdup is higher than the conveyance speed of the developer D in which the rotation speed of the developer conveyance screws **63**, **64** is V. If the distribution of the conveyance speed of the toner carrier C is considered, the minimum value of the conveyance speed distribution of the toner carrier C is used as Vdup of the formula (iii). If the conveyance speed distribution has a narrow width, an average value may be used.

The printing controller **112** makes open the developer discharge shutter **90** at a time that the time lapse from the timing t**22** reaches the time T**3'** or namely at a timing t**24**. In this embodiment, the time T**3'** is a required time for the toner carrier C supplied from the supply unit **70** to circulate once around the conveyance path **62***f*, and the timing t**24** is a time point that the toner carrier C supplied from the supply unit **70** circulates once around the conveyance path **62***f*. The required time may be measured through experiments or may be calculated. For example, where a length of the circulation path **62***f* is set to L, and where a conveyance speed of the toner carrier C is set to Vdup, the time T**3'** is calculated from a formula (iv) below.

$$T3'=L/Vdup \quad \text{(iv)}$$

In consideration of the distribution of the conveyance speed of the toner carrier C, the minimum value of the conveyance speed distribution of the toner carrier C is used for the conveyance speed Vdup in the formula (iv). In a case that the conveyance speed distribution has a narrow width, an average value may be used.

The printing controller **112** starts the supply operation of the second time at the same time as the completion of the supply operation of the first time. The supply operation of the second time is done in substantially the same way as the supply operation of the first time. The supply is made from the timing t**24** to the timing t**25**, and the discharge is prohibited from the timing t**26** to the timing t**27**.

The printing controller **112** controls the rotation speed of the developer conveyance screws **63**, **64** to be back to V from Vup at the end timing of the discharge prohibiting period corresponding to the supply operation of the second time, or namely at the timing t**27**.

As described above, with this embodiment, the developer conveyance screws **63**, **64** raise the conveyance speed of the developer D while the developer D in the prescribed amount is supplied dividedly multiple times from the supply unit **70**. With this operation, the developing device can make shorter the time interval of the supply of the developer D in comparison with a device not increasing the conveyance speed, so that a desired toner density is adjustable in a short period of the time. The amount of the developer D per unit time to be sent to the first conveyance path **62***a* can be made much more, so that this developing device can suppress image failures from occurring due to shortage of the developer D.

With this embodiment, the developer conveyance screws **63**, **64** raise the conveyance speed of the developer D during the discharge prohibiting period. This operation makes shorter the period prohibiting the discharge of the developer D in comparison with a device not increasing the conveyance speed.

It is to be noted that the features of the third embodiment are applicable to the first embodiment. That is, the image forming apparatus according to the first embodiment can be structured so as to increase the conveyance speed of the developer D by means of the developer conveyance screws

63, 64, during a prescribed period, where the developer D is supplied from the supply unit 70.

This invention is not limited to the embodiments described above and can be used in various forms and aspects as far as not deviated from the scope of the invention. For example, although in the above embodiments, the structure that the supply unit 70 supplies the developer D including the toner carrier C and the toner T is exemplified, the supply unit 70 may have a structure supplying at least the toner carrier C and may supply only the toner carrier C instead of the developer D. In such a case, a toner supply unit for supplying the toner T to the circulation path 62*f* may be formed as a separate part of the supply unit 70. The toner supply unit may supply the toner T via the developer supply inlet 72 or may supply the toner T from another portion different from the developer supply inlet 72. The timing supplying the toner T done by the toner supply unit can be the same timing as the timing of the supply of the toner carrier C by the supply unit 70 and can be a different timing. For example, the toner supply unit supplies the toner T when the toner density comes lower than a threshold value, while the supply unit 70 supplies the toner carrier C at each timing that the rotation time of the developer conveyance screws 63, 64 reaches a prescribed time.

In the embodiments described above, the monochrome type image forming apparatus having the single developing device, but this invention is applicable to multicolor image forming apparatuses having plural developing devices. This invention is also applicable to apparatuses other than printers, such as, e.g., photocopiers, facsimile machines, and MFPs (Multi-Function Peripherals)

While only selected embodiments have been chosen to illustrate the present invention, it will be apparent to those skilled in the art from this disclosure that various changes and modifications can be made herein without departing from the scope of the invention as defined in the appended claims. Furthermore, the foregoing descriptions of the embodiments according to the present invention are provided for illustration only, and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.

What is claimed is:

1. A developing device for developing latent images formed on an image carrier with a developer including toner carrier and toner, comprising:

a developer container containing the developer;

a developer conveying member conveying the developer contained in the developer container as stirring the developer to circulate the developer in a circulation path in the developer container;

a supply unit supplying at least the toner carrier to the circulation path;

a discharge unit for discharging excessive developer in the circulation path according to supply from the supply unit; and

a discharge prohibiting unit prohibiting discharge of the developer from the discharge unit during a predetermined discharge prohibiting period in a case where the toner carrier is supplied from the supply unit.

2. The developing device according to claim 1, wherein the discharge prohibiting period includes at least a part of a period that the toner carrier supplied from the supply unit passes through the discharge unit.

3. The developing device according to claim 2, wherein a start timing of the discharge prohibiting period is prior to a timing that the toner carrier supplied from the supply unit reaches the discharge unit.

4. The developing device according to claim 3, wherein the discharge prohibiting period begins simultaneously when the supply unit begins supply of the toner carrier.

5. The developing device according to claim 2, wherein an end timing of the discharge prohibiting period is subsequent to a timing that the toner carrier supplied from the supply unit passes through the discharge unit.

6. The developing device according to claim 2, wherein an end timing of the discharge prohibiting period is subsequent to a timing that the toner carrier supplied from the supply unit circulates once around the circulation path.

7. The developing device according to claim 1, further comprising a judgment unit judging as to whether the developer is to be supplied based on use status of the developer in the circulation path,

wherein the supply unit supplies the developer in a prescribed amount including the toner carrier and the toner to the circulation path when the judgment unit judges as that the developer is to be supplied.

8. The developing device according to claim 7, wherein the supply unit supplies multiple times the developer in the prescribed amount in an intermittently dividing manner.

9. The developing device according to claim 8, wherein the developer conveying member raises a conveyance speed of the developer while the supply unit supplies multiple times the developer in the prescribed amount.

10. The developing device according to claim 1, wherein the developer conveying member raises a conveyance speed of the developer during the discharge prohibiting period.

11. An image forming apparatus comprising:

an image carrier;

a latent image forming unit forming latent images on the image carrier; and

a developing device developing the latent images formed on the image carrier with a developer including toner carrier and toner,

the developing device comprising:

a developer container containing the developer;

a developer conveying member conveying the developer contained in the developer container as stirring the developer to circulate the developer in a circulation path in the developer container;

a supply unit supplying at least the toner carrier to the circulation path;

a discharge unit for discharging excessive developer in the circulation path according to supply from the supply unit; and

a discharge prohibiting unit prohibiting discharge of the developer from the discharge unit during a predetermined discharge prohibiting period in a case where the toner carrier is supplied from the supply unit.

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